

*Examiner's Copy*

AN 126:266821 HCA  
TI High-speed steel rolls with good resistance against heat cracking, wear,  
and surface roughening for hot-rolling  
IN Goto, Kunio; Koide, Taro  
PA Sumitomo Metal Ind, Japan  
SO Jpn. Kokai Tokkyo Koho, 5 pp.  
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	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
PI	JP 09049051	A2	19970218	JP 1995-202102	19950808
AB	At least surface layers of the rolls are made of Fe alloys contg. C 1-3, Si 0.1-2.5, Mn 0.1-2, Cr 2-10, Mo 0.5-8, V 2-8, W 0.5-8, Nb 0.2-5, B 0.005-0.5, Ce 0.001-0.3, Co 0-5, and optionally Ti and/or Zr in total 0.1-2.5%. The appropriate addn. of Ce and B to high-speed steels effectively improves resistance against heat cracking and surface roughening without deteriorating wear resistance due to segregation of Ce and B at grain boundaries.				

0.005-0.5 B

1-3 C

S  
P

2-10 Cr

0.1-2.5 Si

0.5-8 Mo

0.5-8 W

0.2-5 Nb

2-8 V

0-5 Co

0.1-2.2 Mn

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Fe

# PATENT ABSTRACTS OF JAPAN

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(21)Application number : 07-202102

(71)Applicant : SUMITOMO METAL IND LTD

(22)Date of filing : 08.08.1995

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## (54) ROLL FOR HOT ROLLING

### (57)Abstract:

PROBLEM TO BE SOLVED: To produce a roll for hot rolling excellent in thermal cracking resistance, surface roughening resistance and wear resistance, in a hot rolling high speed steel roll, by compositely incorporating specified amounts of B and Ce into a high speed steel roll.

SOLUTION: The componental compsn. at least of a roll outer shell part is composed of, by weight, 1 to 3% C, 0.1 to 2.5% Si, 0.1 to 2% Mn, 2 to 10% Cr, 0.5 to 8% Mo, 2 to 8% V, 0.5 to 8% W, 0.2 to 5% Nb, 0.005 to 0.5% B, 0.001 to 0.3% Ce and 0 to 5% Co, and, if required, one or more kinds of Ti and Zr by 0.1 to 2.5%, and the balance Fe. Thus, B and Ce are segregated into the grain boundaries to increase its high temp. strength and toughness, and its thermal cracking resistance and surface roughening resistance can remarkably be improved without deteriorating its wear resistance.

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**CLAIMS**

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[Claim(s)]

[Claim 1] Component composition of the coat layer of a roll by weight % at least C:1 - 3%, Si: 0.1-2.5%, Mn:0.1-2%, Cr:2-10%, Mo: 0.5-8%, V:2 - 8%, W:0.5 - 8%, Nb:0.2-5%, The roll for hot rolling excellent in the heat-resistant crack nature, surface deterioration-proof nature, and abrasion resistance which are characterized by being Remainder Fe and an unescapable impurity B:0.005 - 0.5%, Ce:0.001-0.3%, and Co:0-5%.

[Claim 2] The roll for hot rolling which was excellent in the heat-resistant crack nature, surface deterioration-proof nature, and abrasion resistance which are characterized by containing one sort of Ti and Zr, or two sorts 0.1 to 2.5% in total by weight % in addition to component composition according to claim 1.

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the roll for rolling excellent in the heat-resistant crack nature used for hot rolling of steel materials etc., surface deterioration-proof nature, and abrasion resistance.

[0002]

[Description of the Prior Art] Conventionally, wear-resistant alloy cast irons which show below the reduction roll used for hot rolling of steel materials, such as a high chrome cast iron of component composition and high-alloy grain cast iron, are used.

[0003] A high chrome cast iron contains C:2.3 - 2.9%, Si:0.4-0.9%, Mn:0.8-1.2%, nickel:0.5-1.5%, Cr:15-20%, and Mo:0.7-2.0%, and the remainder consists of Fe substantially and contains M7C3 type compound carbide 20 to 35% at the rate of area.

[0004] Moreover, high-alloy grain cast iron contains C:3.2 - 3.4%, Si:0.7-0.9%, Mn:0.8-1.2%, nickel:4.2-4.6%, Cr:1.5-1.9%, and Mo:0.3-0.6%, the remainder consists of Fe substantially, and it is M3C. Type carbide is included 25 to 40% at the rate of area. Furthermore, it is roll material for hot rolling which has the outstanding abrasion resistance. Publication number 2-240634 A number official report, JP,2-25205,A, JP,2-88745,A, JP,3-126838,A, JP,3-219047,A, JP,4-141553,A, JP,5-148584,A, and publication number 5-271875 High carbon system high-speed steel (the roll for hot rolling only manufactured with a high speed steel and this steel in such high carbon system high-speed steel is hereafter called hot-rolling highness slow RU) which is indicated by the number official report etc. is used.

[0005] A high speed steel is the high base (Mo, W, Co, etc. are dissolution or detailed carbide all over a base.) of the carbide of a high degree of hardness [ type / MC ] and the compound carbide, such as an M2C type, which make V carbide a subject into a metal texture, and elevated-temperature softening resistance. Type and M6C depositing -- depending -- since it has, especially when this is used as roll material for hot rolling, it is said that the outstanding abrasion resistance between heat is demonstrated

[0006] In the hot rolling by hot-rolling highness slow RU, although a reason is not necessarily certain, in a rolled-stock-ed front face, it is easy to generate the crack (biting lump scale crack) which bit the scale. It is thought that the hot-rolling high-speed-steel roll is the cause of generating the surface crack which roll surface deterioration bites by being easy to produce the roll surface deterioration by ablation (banding) of the scale on the front face of a roll, and is represented by the lump scale crack, and reducing the quality of a flat rolled product.

[0007] Furthermore, in the hot rolling by hot-rolling highness slow RU, bite, conventionally, since it is deep compared with a roll, in the amount of grinding at the time of roll repair, it increased and the heat check [ (trouble which rotation of a roll stops the moment the steel plate bit on the roll) ] by the thermal shock at the time of unusual rolling like narrowing down (rolling in the state where the nose of cam and the back end of a rolled stock lapped) has invited large aggravation of a roll material unit.

[0008]

[Problem(s) to be Solved by the Invention] The purpose of this invention solves the above-mentioned trouble generated in hot-rolling highness slow RU, and is to offer the roll for hot rolling excellent in the high productivity in hot rolling and heat-resistant crack nature required for quality improvement of a flat rolled product, surface deterioration-proof nature, and abrasion resistance.

[0009]

[Means for Solving the Problem] The result to which this invention person examined wholeheartedly how to solve the aforementioned trouble produced in conventional hot-rolling highness slow RU, Without spoiling abrasion resistance by making a high speed steel contain B and Ce by composite It comes to know that heat-resistant crack nature (resistance over the heat-check depth) and surface deterioration-proof nature will improve by leaps and bounds, and this invention is completed. the summary "Component composition of the coat layer of a roll by weight % at least C:1 - 3%, Si: 0.1-2.5%, Mn:0.1-2%, Cr:2-10%, Mo: 0.5-8%, V:2 - 8%, W:0.5 - 8%, Nb:0.2-5%, B:0.005 - 0.5%, Ce:0.001-0.3%, and Co:0-5% are contained. It is in the roll for hot rolling which was excellent in total at the abrasion resistance, the heat-resistant crack nature, and surface deterioration-proof nature which are characterized by being Remainder Fe and an unescapable impurity including 0.1 - 2.5% about one sort of Ti and Zr, or two sorts as occasion demands."

[0010] here, it can set "for it to be a coat layer at least" -- at least -- \*\*\*\* -- the coat layer of a roll is surely making it the above-mentioned component composition, and it means that the other portion may be made the same composition as a coat layer, and other materials like a ductile cast iron may be used [ which is limited above ] Moreover, a coat layer is a surface layer of a rolling use layer slack roll, and especially thickness is not limited.

[0011] If compound addition of Ce and the B is carried out at a high speed steel, it will be hard coming to carry out the plastic flow (wear and surface deterioration) of them by carrying out a segregation to the grain boundary and raising the intensity in an elevated temperature, and toughness. Consequently, the improvement of abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature can be performed.

[0012]

[Embodiments of the Invention] The reason for limitation of component composition (% of the weight) of the coat layer of the roll for hot rolling concerning this invention is explained.

[0013] C:1 - 3%C combines with Cr, Mo, W, V, Nb, Ti, and Zr, and is MC type and M<sub>6</sub>C while it mainly combines with Fe and Cr and forms the M<sub>7</sub>C<sub>3</sub> type compound carbide of a high degree of hardness. There is work which forms the compound carbide of a high degree of hardness, such as type and an M<sub>2</sub>C type, and raises the abrasion resistance of a roll. The content of C has few amounts of generation of the carbide of the above-mentioned quantity degree of hardness at less than 1%, and the abrasion resistance between heat runs short. On the other hand, if contained exceeding 3%, the amount of deposits of the amount of carbide of a high degree of hardness will increase too much, and toughness and heat-resistant crack nature will fall. Therefore, C content could be 1 - 3%.

[0014] Si: 0.1 - 2.5%Si is effective in improving the deoxidation and fluidity nature of a molten metal. At less than 0.1%, the above-mentioned effects run short, and if it exceeds 2.5% on the other hand, toughness and a mechanical property will deteriorate. Therefore, Si content could be 0.1 - 2.5%.

[0015] Mn: 0.1 - 2%Mn is an element required in order to fix as MnS S which is an impurity and to improve processability with deacidification. Effect sufficient at less than 0.1% is not acquired, but if it exceeds 2% on the other hand, toughness will fall. Therefore, Mn content could be 0.1 - 2%.

[0016] Cr: 2-10%Cr dissolves all over a base, and strengthens a base, and also it combines with C. M<sub>7</sub>C<sub>3</sub> There is an operation which deposits the compound carbide of a high degree of hardness of a system, and raises abrasion resistance and toughness. However, at less than 2%, if those effects are not acquired enough but exceed 10% on the other hand, while carbide will make it big and rough, the amount also becomes superfluous and heat-resistant crack nature, surface deterioration-proof nature, and toughness fall. Therefore, Cr content may be 2 - 10%.

[0017] Mo: 0.5 - 8%Mo dissolves on a base, makes elevated-temperature softening resistance improve, and also combines with C and is M<sub>6</sub>C. Type and M<sub>2</sub>C Compound carbide, such as type, is formed and there is an operation which raises abrasion resistance. However, at less than 0.5%, the above-mentioned effect is not acquired enough. On the other hand, the fall of toughness will be caused if it exceeds 8%. Therefore, Mo content may be 0.5 - 8%.

[0018] It turns crystal grain minutely and raises toughness while V:2 - 8%V combines with C, forms the MC type compound carbide of a high degree of hardness and raises abrasion resistance. However, at less than 2%, if the effect adds exceeding a few fence, one side, and 8%, the fall of toughness will take place, and also the roll itself becomes easy to oxidize and degradation of surface deterioration-proof nature is caused. Therefore, V content may be 1 - 8%.

[0019] With Fe, Cr, Mo, V, Nb, etc., W:0.5 - 8%W combines with C, forms the compound carbide of a high

degree of hardness, and raises abrasion resistance. Moreover, it dissolves on a base and tempering softening resistance is raised. However, at less than 0.5%, those effects cannot be acquired, but if it exceeds 8% on the other hand, toughness and heat-resistant crack nature will be reduced, and also it becomes easy to cause a segregation. Therefore, the amount of W is made into 0.5 - 8%.

[0020] Nb: 0.2-5.0%Nb combines with C like V, forms the carbide of a high degree of hardness, and has the work which raises abrasion resistance. Moreover, an organization is turned minutely and toughness and heat-resistant crack nature are raised. If the content of Nb cannot acquire the above-mentioned effect enough but exceeds 5% on the other hand at less than 0.2%, toughness and heat-resistant crack nature will fall. Therefore, Nb content may be 0.2 - 5%.

[0021] B: 0.005 - 0.5%B is an important element in this invention. B combines with the oxygen in a molten metal, and shows the deoxidation effect. Moreover, by carrying out minute amount compound addition with Ce, a deposit segregation is minutely carried out to the grain boundary, the intensity in an elevated temperature and toughness are raised, and a plastic flow is suppressed. Consequently, since abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature improve, and also the oxidation resistance of a high speed steel is raised and the generation of the scale on the front face of a roll itself is suppressed, the surface deterioration on the front face of a roll (scale ablation) can be prevented.

[0022] If the amount of B runs short of the above-mentioned effects and exceeds 0.5% on the other hand at 0.005% or less, the quality of the material will become weak. Therefore, B content could be 0.005 - 0.5%.

[0023] Ce: 0.001-0.3%Ce as well as B is an important element in this invention. By carrying out minute amount compound addition with B, the segregation of the Ce is carried out to the grain boundary, and it raises the intensity and plastic-flow nature in an elevated temperature.

[0024] Consequently, since abrasion resistance and heat-resistant crack nature improve, and also the oxidation resistance of a high speed steel is raised and the generation of the scale on the front face of a roll itself is suppressed, the surface deterioration on the front face of a roll (scale ablation) can be prevented.

[0025] If the amount of Ce(s) cannot fully acquire the above-mentioned effect but exceeds 0.3% on the other hand at 0.001% or less, the quality of the material will become weak. Therefore, Ce content could be 0.001 - 0.3%.

[0026] Co: Since the most dissolves on a base, and raises the degree of hardness of a base and also 0-5%Co has the operation which raises elevated-temperature softening resistance and improves abrasion resistance, adding if needed is desirable. In order to acquire sufficient effect, it is desirable to make it contain 0.2% or more. If it exceeds 5%, the segregation of carbide will be promoted and the toughness of a base will be reduced. Therefore, the upper limit of Co was made into 5% or less.

[0027] Ti, Zr: 1 sort, or two sorts of sum totals are useful to the wear-resistant improvement and toughening of an organization by detailed-izing, and make Ti and Zr contain as occasion demands 0.1 to 2.5%. If these contents cannot acquire the above-mentioned effect enough but exceed 2.5% on the other hand at less than 0.1% in total, toughness and a mechanical property will deteriorate remarkably.

[0028] Therefore, one sort or two sorts of sum totals, Ti and Zr, could be 0.1 - 2.5%.

[0029] Although P and S as an impurity are contained unescapable, since they cause degradation of a mechanical property, its fewer one is good and it is desirable to make it to 0.08% or less.

[0030] The roll for hot rolling of this invention may be the component composition with the whole above-mentioned roll, and a inner layer may be a compound roll which are other steel in component composition of the above, the surface section, i.e., the coat layer, of a roll. Especially this coat layer thickness does not limit.

[0031] In the case of the latter, tough material, such as a ductile cast iron, common cast iron, a graphitization cast iron, a spheroidal graphite cast iron, forged steel, and steel casting, can be used as inner layer material.

[0032] Moreover, the roll for hot rolling of this invention can be manufactured using powder-metallurgy processing currently indicated by the continuation padding method of having used the high-frequency heating currently indicated by a spun casting method, JP,44-4903,B, etc., JP,47-2851,A, etc. by the one roll manufacture methods, such as the compound-roll manufacture methods, such as the method of fabricating a coat layer with the hydrostatic pressure between heat, and the building-up method using the electroslog melting currently indicated by JP,57-2862,A, and gentle placement casting, forging, etc.

[0033] The roll for hot rolling of this invention is applicable to all rolls used between [ other than the work roll of the finishing mill between heat ] heat, such as a roll for hot skin pass mills, a roll for bar-steel rolling, and various rolls for tube manufacturing.

[0034] The following, a book

[0035]

[Example] In inner layer material, 17 kinds of compound rolls were really manufactured by the forging method using the high carbon system high-speed steel of the component composition shown in Table 1 as a coat layer using the ductile cast iron. The roll size was as follows.

[0036] Drum-section diameter: 150 mm, drum length:300 mm, overall-length:510 mm. [0037]

[Table 1]

表 1

鋼 No.	化 学 組 成 (重量%)										残部:Feと不可避免的不純物				TiとZrの 合計量	備考
	C	Si	Mn	Cr	Mo	V	W	Nb	B	Ce	Co	Ti	Zr			
1	1.8	0.7	0.6	3.5	3.8	3.0	0.5	0.2	0.01	0.005	-	-	-	0	本 発 明 例	
2	2.1	0.7	0.5	4.2	4.2	4.9	3.0	1.8	0.03	0.012	-	-	-	0		
3	2.2	0.7	0.6	5.1	4.1	5.9	5.1	1.2	0.10	0.054	-	-	-	0		
4	2.5	0.6	0.5	4.5	3.8	5.3	5.8	1.1	0.34	0.083	-	-	-	0		
5	2.5	0.7	0.4	3.8	2.9	6.8	6.9	1.2	0.02	0.201	-	-	-	0		
6	1.8	0.5	0.5	2.9	4.3	3.5	4.7	1.5	0.03	0.011	1.1	-	-	0		
7	1.7	0.7	0.4	3.0	4.5	3.2	4.9	2.0	0.03	0.015	4.9	-	-	0		
8	2.3	0.6	0.6	7.1	3.5	5.0	0.6	2.8	0.02	0.023	-	0.2	-	0.2		
9	2.4	0.7	0.4	5.5	3.1	5.3	0.6	2.9	0.03	0.021	-	-	0.6	0.6		
10	2.3	0.6	0.5	7.2	3.3	3.1	0.6	2.8	0.02	0.025	-	1.0	1.2	2.2		
11	2.5	0.7	0.6	2.8	5.0	4.0	2.0	4.0	0.04	0.017	1.9	0.5	0.6	1.1		
12	1.7	0.7	0.6	3.6	3.8	3.1	0.5	0.3	- *	- *	-	-	-	0	比 較 例	
13	1.8	0.6	0.7	3.8	3.9	3.3	0.6	0.3	0.03	- *	-	-	-	0		
14	2.0	0.7	0.6	4.5	2.8	4.0	0.9	0.5	- *	0.013	-	-	-	0		
15	2.5	0.7	0.5	5.7	4.5	5.2	4.5	2.8	0.71 *	0.015	-	-	-	0		
16	2.5	0.6	0.6	6.0	5.0	4.9	4.8	3.0	0.04	0.550*	-	-	-	0		
17	2.6	0.7	0.7	5.8	4.9	4.5	4.7	2.6	0.75 *	0.565*	1.8	0.3	0.3	0.6		

\* 本発明で規定する範囲外を示す。

[0038] No.1-11 are the roll of the former [ 17 / No.12 -/ the roll of this invention, and ]. Each roll adjusted surface hardness to Hs 83-85 by heat-treating hardening at 1050-1150 degrees C, and annealing by 500 - 580

\*\*

[0039] These rolls were incorporated as a work roll of the four-step formula rolling mill (reinforcement roll shell-diameter 300 mm) of the coil rolling experiment equipment between heat which simulated hot rolling of sheet steel, and the carbon steel plate (board thickness:1mm, board width:40mm, and coil-length:2000m (SPCC coil)) was hot-rolled on condition that the following.

[0040] Rolling reduction :40% rolling temperature : 1000 degrees C, rolling speed : Lubricous by 200m/ : The greatest wear depth was measured for the commercial hot rolling oil from the roll profile after the direct supply-pressure total from the entering side to the work roll with the water injection method, and abrasion resistance was evaluated. Moreover, the test piece of a 10mmx10mmx10mm size was extracted from the center-section surface section of the direction of roll axis after rolling, the maximum depth of a crack was measured with the optical microscope, and heat-resistant crack nature was evaluated. Furthermore, the grade of ablation generating of the scale on the front face of a roll after rolling was observed visually, and surface deterioration-proof nature was evaluated. The result is shown in Table 2.

[0041]

[Table 2]



表 2

鋼 No.	耐摩耗性 <sup>1)</sup>	耐熱亀裂性 <sup>2)</sup>	耐肌荒れ性 <sup>3)</sup>	備 考
1	10.5 $\mu\text{m}$	4 $\mu\text{m}$	なし	本 発 明 例
2	8.8 $\mu\text{m}$	6 $\mu\text{m}$	なし	
3	5.3 $\mu\text{m}$	6 $\mu\text{m}$	なし	
4	2.2 $\mu\text{m}$	9 $\mu\text{m}$	なし	
5	5.4 $\mu\text{m}$	8 $\mu\text{m}$	なし	
6	7.4 $\mu\text{m}$	2 $\mu\text{m}$	なし	
7	4.1 $\mu\text{m}$	2 $\mu\text{m}$	なし	
8	4.8 $\mu\text{m}$	11 $\mu\text{m}$	なし	
9	4.3 $\mu\text{m}$	12 $\mu\text{m}$	なし	
10	3.9 $\mu\text{m}$	14 $\mu\text{m}$	なし	
11	2.0 $\mu\text{m}$	10 $\mu\text{m}$	なし	
12	28.5 $\mu\text{m}$	89 $\mu\text{m}$	全面に黒皮剝離発生	比 較 例
13	24.4 $\mu\text{m}$	57 $\mu\text{m}$	全面に黒皮剝離発生	
14	27.3 $\mu\text{m}$	65 $\mu\text{m}$	全面に黒皮剝離発生	
15	8.5 $\mu\text{m}$	68 $\mu\text{m}$	部分的に黒皮剝離発生	
16	7.5 $\mu\text{m}$	94 $\mu\text{m}$	部分的に黒皮剝離発生	
17	3.5 $\mu\text{m}$	120 $\mu\text{m}$	なし	

1) 耐摩耗性は、圧延後の最大摩耗深さによる評価

2) 耐熱亀裂性は、圧延後の最大熱亀裂深さによる評価

3) 耐肌荒れ性は、黒皮剝離の目視観察による評価

[0042] this \*\* -- the Ming kana -- example of this invention which carries out compound content with B and Ce like No.1 -5 Example No.of comparison 12 containing neither B nor Ce It turns out that both abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature are improving by leaps and bounds compared with example No.of comparison 13 only containing one of the two of B or Ce, and 14.

[0043] Moreover, example No.of comparison 15 to which B exceeds 0.5% and example No.of comparison 16 to which Ce exceeds 0.3% And example No.of comparison 17 to which both the contents of B and Ce exceed the range of this invention Example of this invention No.2 When compared, although some abrasion resistance and surface deterioration-proof nature improve, they are understood that heat-resistant crack nature is inadequate. moreover, example of this invention No.2 No. -- 6 and 7 From comparison, abrasion resistance and heat-resistant crack nature are further improved by making Co contain.

[0044] example of this invention No.5 No. -- 8 and 9 From comparison, abrasion resistance is improving further by containing Ti and Zr.

[0045] Furthermore, example of this invention When Co, Ti, and Zr contain like No.11, abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature are improving with sufficient balance.

[0046]

[Effect of the Invention] According to the roll for hot rolling of this invention, it has the outstanding heat-resistant crack nature, surface deterioration-proof nature, and abrasion resistance, and extension of a roll life, reduction of roll exchange frequency, improvement in a roll material unit, etc. can be attained, consequently upgrading and the high productivity of a flat rolled product can be realized. And this roll demonstrates the endurance which was excellent also in severe rolling conditions regardless of the rolled-steel kind.

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**TECHNICAL FIELD**

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[The technical field to which invention belongs] this invention relates to the roll for rolling excellent in the heat-resistant crack nature used for hot rolling of steel materials etc., surface deterioration-proof nature, and abrasion resistance.

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**PRIOR ART**

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[Description of the Prior Art] Conventionally, wear-resistant alloy cast irons which show below the reduction roll used for hot rolling of steel materials, such as a high chrome cast iron of component composition and high-alloy grain cast iron, are used.

[0003] A high chrome cast iron contains C:2.3 - 2.9%, Si:0.4-0.9%, Mn:0.8-1.2%, nickel:0.5-1.5%, Cr:15-20%, and Mo:0.7-2.0%, and the remainder consists of Fe substantially and contains M7C3 type compound carbide 20 to 35% at the rate of area.

[0004] Moreover, high-alloy grain cast iron contains C:3.2 - 3.4%, Si:0.7-0.9%, Mn:0.8-1.2%, nickel:4.2-4.6%, Cr:1.5-1.9%, and Mo:0.3-0.6%, the remainder consists of Fe substantially, and it is M3C. Type carbide is included 25 to 40% at the rate of area. Furthermore, it is roll material for hot rolling which has the outstanding abrasion resistance. Publication number 2-240634 A number official report, JP,2-25205,A, JP,2-88745,A, JP,3-126838,A, JP,3-219047,A, JP,4-141553,A, JP,5-148584,A, and publication number 5-271875 High carbon system high-speed steel (the roll for hot rolling only manufactured with a high speed steel and this steel in such high carbon system high-speed steel is hereafter called hot-rolling highness slow RU) which is indicated by the number official report etc. is used.

[0005] A high speed steel is the high base (Mo, W, Co, etc. are dissolution or detailed carbide all over a base.) of the carbide of a high degree of hardness [ type / MC ] and the compound carbide, such as an M2C type, which make V carbide a subject into a metal texture, and elevated-temperature softening resistance. Type and M6C depositing -- depending -- since it has, especially when this is used as roll material for hot rolling, it is said that the outstanding abrasion resistance between heat is demonstrated

[0006] In the hot rolling by hot-rolling highness slow RU, although a reason is not necessarily certain, in a rolled-stock-ed front face, it is easy to generate the crack (biting lump scale crack) which bit the scale. It is thought that the hot-rolling high-speed-steel roll is the cause of generating the surface crack which roll surface deterioration bites by being easy to produce the roll surface deterioration by ablation (banding) of the scale on the front face of a roll, and is represented by the lump scale crack, and reducing the quality of a flat rolled product.

[0007] Furthermore, in the hot rolling by hot-rolling highness slow RU, bite, conventionally, since it is deep compared with a roll, in the amount of grinding at the time of roll repair, it increased and the heat check [ (trouble which rotation of a roll stops the moment the steel plate bit on the roll) ] by the thermal shock at the time of unusual rolling like narrowing down (rolling in the state where the nose of cam and the back end of a rolled stock lapped) has invited large aggravation of a roll material unit.

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[Translation done.]

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**EFFECT OF THE INVENTION**

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[Effect of the Invention] According to the roll for hot rolling of this invention, it has the outstanding heat-resistant crack nature, surface deterioration-proof nature, and abrasion resistance, and extension of a roll life, reduction of roll exchange frequency, improvement in a roll material unit, etc. can be attained, consequently upgrading and the high productivity of a flat rolled product can be realized. And this roll demonstrates the endurance which was excellent also in severe rolling conditions regardless of the rolled-steel kind.

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**TECHNICAL PROBLEM**

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[Problem(s) to be Solved by the Invention] The purpose of this invention solves the above-mentioned trouble generated in hot-rolling highness slow RU, and is to offer the roll for hot rolling excellent in the high productivity in hot rolling and heat-resistant crack nature required for quality improvement of a flat rolled product, surface deterioration-proof nature, and abrasion resistance.

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**MEANS**

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[Means for Solving the Problem] The result to which this invention person examined wholeheartedly how to solve the aforementioned trouble produced in conventional hot-rolling highness slow RU, Without spoiling abrasion resistance by making a high speed steel contain B and Ce by composite It comes to know that heat-resistant crack nature (resistance over the heat-check depth) and surface deterioration-proof nature will improve by leaps and bounds, and this invention is completed. the summary "Component composition of the coat layer of a roll by weight % at least C:1 - 3%, Si: 0.1-2.5%, Mn:0.1-2%, Cr:2-10%, Mo: 0.5-8%, V:2 - 8%, W:0.5 - 8%, Nb:0.2-5%, B:0.005 - 0.5%, Ce:0.001-0.3%, and Co:0-5% are contained. It is in the roll for hot rolling which was excellent in total at the abrasion resistance, the heat-resistant crack nature, and surface deterioration-proof nature which are characterized by being Remainder Fe and an unescapable impurity including 0.1 - 2.5% about one sort of Ti and Zr, or two sorts as occasion demands."

[0010] here, it can set "for it to be a coat layer at least" -- at least -- \*\*\*\* -- the coat layer of a roll is surely making it the above-mentioned component composition, and it means that the other portion may be made the same composition as a coat layer, and other materials like a ductile cast iron may be used [ which is limited above ] Moreover, a coat layer is a surface layer of a rolling use layer slack roll, and especially thickness is not limited.

[0011] If compound addition of Ce and the B is carried out at a high speed steel, it will be hard coming to carry out the plastic flow (wear and surface deterioration) of them by carrying out a segregation to the grain boundary and raising the intensity in an elevated temperature, and toughness. Consequently, the improvement of abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature can be performed.

[0012]

[Embodiments of the Invention] The reason for limitation of component composition (% of the weight) of the coat layer of the roll for hot rolling concerning this invention is explained.

[0013] C:1 - 3%C combines with Cr, Mo, W, V, Nb, Ti, and Zr, and is MC type and M<sub>6</sub>C while it mainly combines with Fe and Cr and forms the M<sub>7</sub>C<sub>3</sub> type compound carbide of a high degree of hardness. There is work which forms the compound carbide of a high degree of hardness, such as type and an M<sub>2</sub>C type, and raises the abrasion resistance of a roll. The content of C has few amounts of generation of the carbide of the above-mentioned quantity degree of hardness at less than 1%, and the abrasion resistance between heat runs short. On the other hand, if contained exceeding 3%, the amount of deposits of the amount of carbide of a high degree of hardness will increase too much, and toughness and heat-resistant crack nature will fall. Therefore, C content could be 1 - 3%.

[0014] Si: 0.1 - 2.5%Si is effective in improving the deoxidation and fluidity nature of a molten metal. At less than 0.1%, the above-mentioned effects run short, and if it exceeds 2.5% on the other hand, toughness and a mechanical property will deteriorate. Therefore, Si content could be 0.1 - 2.5%.

[0015] Mn: 0.1 - 2%Mn is an element required in order to fix as MnS S which is an impurity and to improve processability with deacidification. Effect sufficient at less than 0.1% is not acquired, but if it exceeds 2% on the other hand, toughness will fall. Therefore, Mn content could be 0.1 - 2%.

[0016] Cr: 2-10%Cr dissolves all over a base, and strengthens a base, and also it combines with C. M<sub>7</sub>C<sub>3</sub> There is an operation which deposits the compound carbide of a high degree of hardness of a system, and raises abrasion resistance and toughness. However, at less than 2%, if those effects are not acquired enough but exceed 10% on the other hand, while carbide will make it big and rough, the amount also becomes superfluous and heat-resistant crack nature, surface deterioration-proof nature, and toughness fall. Therefore, Cr content may be 2 - 10%.

[0017] Mo: 0.5 - 8%Mo dissolves on a base, makes elevated-temperature softening resistance improve, and also combines with C and is M6C. Type and M2C Compound carbide, such as type, is formed and there is an operation which raises abrasion resistance. However, at less than 0.5%, the above-mentioned effect is not acquired enough. On the other hand, the fall of toughness will be caused if it exceeds 8%. Therefore, Mo content may be 0.5 - 8%.

[0018] It turns crystal grain minutely and raises toughness while V:2 - 8%V combines with C, forms the MC type compound carbide of a high degree of hardness and raises abrasion resistance. However, at less than 2%, if the effect adds exceeding a few fence, one side, and 8%, the fall of toughness will take place, and also the roll itself becomes easy to oxidize and degradation of surface deterioration-proof nature is caused. Therefore, V content may be 1 - 8%.

[0019] With Fe, Cr, Mo, V, Nb, etc., W:0.5 - 8%W combines with C, forms the compound carbide of a high degree of hardness, and raises abrasion resistance. Moreover, it dissolves on a base and tempering softening resistance is raised. However, at less than 0.5%, those effects cannot be acquired, but if it exceeds 8% on the other hand, toughness and heat-resistant crack nature will be reduced, and also it becomes easy to cause a segregation. Therefore, the amount of W is made into 0.5 - 8%.

[0020] Nb: 0.2-5.0%Nb combines with C like V, forms the carbide of a high degree of hardness, and has the work which raises abrasion resistance. Moreover, an organization is turned minutely and toughness and heat-resistant crack nature are raised. If the content of Nb cannot acquire the above-mentioned effect enough but exceeds 5% on the other hand at less than 0.2%, toughness and heat-resistant crack nature will fall. Therefore, Nb content may be 0.2 - 5%.

[0021] B:0.005 - 0.5%B is an important element in this invention. B combines with the oxygen in a molten metal, and shows the deoxidation effect. Moreover, by carrying out minute amount compound addition with Ce, a deposit segregation is minutely carried out to the grain boundary, the intensity in an elevated temperature and toughness are raised, and a plastic flow is suppressed. Consequently, since abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature improve, and also the oxidation resistance of a high speed steel is raised and the generation of the scale on the front face of a roll itself is suppressed, the surface deterioration on the front face of a roll (scale ablation) can be prevented.

[0022] If the amount of B runs short of the above-mentioned effects and exceeds 0.5% on the other hand at 0.005% or less, the quality of the material will become weak. Therefore, B content could be 0.005 - 0.5%.

[0023] Ce: 0.001-0.3%Ce as well as B is an important element in this invention. By carrying out minute amount compound addition with B, the segregation of the Ce is carried out to the grain boundary, and it raises the intensity and plastic-flow nature in an elevated temperature.

[0024] Consequently, since abrasion resistance and heat-resistant crack nature improve, and also the oxidation resistance of a high speed steel is raised and the generation of the scale on the front face of a roll itself is suppressed, the surface deterioration on the front face of a roll (scale ablation) can be prevented.

[0025] If the amount of Ce(s) cannot fully acquire the above-mentioned effect but exceeds 0.3% on the other hand at 0.001% or less, the quality of the material will become weak. Therefore, Ce content could be 0.001 - 0.3%.

[0026] Co: Since the most dissolves on a base, and raises the degree of hardness of a base and also 0-5%Co has the operation which raises elevated-temperature softening resistance and improves abrasion resistance, adding if needed is desirable. In order to acquire sufficient effect, it is desirable to make it contain 0.2% or more. If it exceeds 5%, the segregation of carbide will be promoted and the toughness of a base will be reduced. Therefore, the upper limit of Co was made into 5% or less.

[0027] Ti, Zr:1 sort, or two sorts of sum totals are useful to the wear-resistant improvement and toughening of an organization by detailed-izing, and make Ti and Zr contain as occasion demands 0.1 to 2.5%. If these contents cannot acquire the above-mentioned effect enough but exceed 2.5% on the other hand at less than 0.1% in total, toughness and a mechanical property will deteriorate remarkably.

[0028] Therefore, one sort or two sorts of sum totals, Ti and Zr, could be 0.1 - 2.5%.

[0029] Although P and S as an impurity are contained unescapable, since they cause degradation of a mechanical property, its fewer one is good and it is desirable to make it to 0.08% or less.

[0030] The roll for hot rolling of this invention may be the component composition with the whole above-mentioned roll, and a inner layer may be a compound roll which are other steel in component composition of the above, the surface section, i.e., the coat layer, of a roll. Especially this coat layer thickness does not limit.

[0031] In the case of the latter, tough material, such as a ductile cast iron, common cast iron, a graphitization cast iron, a spheroidal graphite cast iron, forged steel, and steel casting, can be used as inner layer material.

[0032] Moreover, the roll for hot rolling of this invention can be manufactured using powder-metallurgy processing currently indicated by the continuation padding method of having used the high-frequency heating currently indicated by a spun casting method, JP,44-4903,B, etc., JP,47-2851,A, etc. by the one roll manufacture methods, such as the compound-roll manufacture methods, such as the method of fabricating a coat layer with the hydrostatic pressure between heat, and the building-up method using the electrosag melting currently indicated by JP,57-2862,A, and gentle placement casting, forging, etc.

[0033] The roll for hot rolling of this invention is applicable to all rolls used between [ other than the work roll of the finishing mill between heat ] heat, such as a roll for hot skin pass mills, a roll for bar-steel rolling, and various rolls for tube manufacturing.

[0034] The following, a book

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EXAMPLE

[Example] In inner layer material, 17 kinds of compound rolls were really manufactured by the forging method using the high carbon system high-speed steel of the component composition shown in Table 1 as a coat layer using the ductile cast iron. The roll size was as follows.

[0036] Drum-section diameter: 150 mm, drum length: 300 mm, overall-length: 510 mm. [0037]

[Table 1]

表 1

鋼 No.	化 学 組 成 (重量%)											残部: Feと不可避免の不純物		TiとZrの 合計量	備考
	C	Si	Mn	Cr	Mo	V	W	Nb	B	Ce	Co	Ti	Zr		
1	1.8	0.7	0.6	3.5	3.8	3.0	0.5	0.2	0.01	0.005	-	-	-	0	本 発 明 例
2	2.1	0.7	0.5	4.2	4.2	4.9	3.0	1.8	0.03	0.012	-	-	-	0	
3	2.2	0.7	0.6	5.1	4.1	5.9	5.1	1.2	0.10	0.054	-	-	-	0	
4	2.5	0.6	0.5	4.5	3.8	5.3	5.8	1.1	0.34	0.083	-	-	-	0	
5	2.5	0.7	0.4	3.8	2.9	6.8	6.9	1.2	0.02	0.201	-	-	-	0	
6	1.8	0.5	0.5	2.9	4.3	3.5	4.7	1.5	0.03	0.011	1.1	-	-	0	
7	1.7	0.7	0.4	3.0	4.5	3.2	4.9	2.0	0.03	0.015	4.9	-	-	0	
8	2.3	0.6	0.6	7.1	3.5	5.0	0.6	2.8	0.02	0.023	-	0.2	-	0.2	
9	2.4	0.7	0.4	5.5	3.1	5.3	0.6	2.9	0.03	0.021	-	-	0.6	0.6	
10	2.3	0.6	0.5	7.2	3.3	3.1	0.6	2.8	0.02	0.025	-	1.0	1.2	2.2	
11	2.5	0.7	0.6	2.8	5.0	4.0	2.0	4.0	0.04	0.017	1.9	0.5	0.6	1.1	
12	1.7	0.7	0.6	3.6	3.8	3.1	0.5	0.3	- *	- *	-	-	-	0	比 較 例
13	1.8	0.6	0.7	3.8	3.9	3.3	0.6	0.3	0.03	- *	-	-	-	0	
14	2.0	0.7	0.6	4.5	2.8	4.0	0.9	0.5	- *	0.013	-	-	-	0	
15	2.5	0.7	0.5	5.7	4.5	5.2	4.5	2.8	0.71 *	0.015	-	-	-	0	
16	2.5	0.6	0.6	6.0	5.0	4.9	4.8	3.0	0.04	0.550*	-	-	-	0	
17	2.6	0.7	0.7	5.8	4.9	4.5	4.7	2.6	0.75 *	0.565*	1.8	0.3	0.3	0.6	

\* 本発明で規定する範囲外を示す。

[0038] No. 1-11 are the roll of the former [ 17 / No. 12 -/ the roll of this invention, and ]. Each roll adjusted surface hardness to Hs 83-85 by heat-treating hardening at 1050-1150 degrees C, and annealing by 500 - 580

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[0039] These rolls were incorporated as a work roll of the four-step formula rolling mill (reinforcement roll shell-diameter 300 mm) of the coil rolling experiment equipment between heat which simulated hot rolling of sheet steel, and the carbon steel plate (board thickness: 1mm, board width: 40mm, and coil-length: 2000m (SPCC coil)) was hot-rolled on condition that the following.

[0040] Rolling reduction : 40% rolling temperature : 1000 degrees C, rolling speed : Lubricous by 200m/ : The greatest wear depth was measured for the commercial hot rolling oil from the roll profile after the direct supply-pressure total from the entering side to the work roll with the water injection method, and abrasion resistance was evaluated. Moreover, the test piece of a 10mmx10mmx10mm size was extracted from the center-section surface section of the direction of roll axis after rolling, the maximum depth of a crack was measured with the optical microscope, and heat-resistant crack nature was evaluated. Furthermore, the grade of exfoliation

generating of the scale on the front face of a roll after rolling was observed visually, and surface deterioration-proof nature was evaluated. The result is shown in Table 2.

[0041]

[Table 2]

表 2

鋼 No.	耐摩耗性 <sup>1)</sup>	耐熱亀裂性 <sup>2)</sup>	耐肌荒れ性 <sup>3)</sup>	備 考
1	10.5 $\mu\text{m}$	4 $\mu\text{m}$	なし	本 発 明 例
2	8.8 $\mu\text{m}$	6 $\mu\text{m}$	なし	
3	5.3 $\mu\text{m}$	6 $\mu\text{m}$	なし	
4	2.2 $\mu\text{m}$	9 $\mu\text{m}$	なし	
5	5.4 $\mu\text{m}$	8 $\mu\text{m}$	なし	
6	7.4 $\mu\text{m}$	2 $\mu\text{m}$	なし	
7	4.1 $\mu\text{m}$	2 $\mu\text{m}$	なし	
8	4.8 $\mu\text{m}$	11 $\mu\text{m}$	なし	
9	4.3 $\mu\text{m}$	12 $\mu\text{m}$	なし	
10	3.9 $\mu\text{m}$	14 $\mu\text{m}$	なし	
11	2.0 $\mu\text{m}$	10 $\mu\text{m}$	なし	
12	28.5 $\mu\text{m}$	89 $\mu\text{m}$	全面に黒皮剝離発生	比 較 例
13	24.4 $\mu\text{m}$	57 $\mu\text{m}$	全面に黒皮剝離発生	
14	27.3 $\mu\text{m}$	65 $\mu\text{m}$	全面に黒皮剝離発生	
15	8.5 $\mu\text{m}$	68 $\mu\text{m}$	部分的に黒皮剝離発生	
16	7.5 $\mu\text{m}$	94 $\mu\text{m}$	部分的に黒皮剝離発生	
17	3.5 $\mu\text{m}$	120 $\mu\text{m}$	なし	

1) 耐摩耗性は、圧延後の最大摩耗深さによる評価

2) 耐熱亀裂性は、圧延後の最大熱亀裂深さによる評価

3) 耐肌荒れ性は、黒皮剝離の目視観察による評価

[0042] this \*\* -- the Ming kana -- example of this invention which carries out compound content with B and Ce like No.1 -5 Example No.of comparison 12 containing neither B nor Ce It turns out that both abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature are improving by leaps and bounds compared with example No.of comparison 13 only containing one of the two of B or Ce, and 14.

[0043] Moreover, example No.of comparison 15 to which B exceeds 0.5% and example No.of comparison 16 to which Ce exceeds 0.3% And example No.of comparison 17 to which both the contents of B and Ce exceed the range of this invention Example of this invention No.2 When compared, although some abrasion resistance and surface deterioration-proof nature improve, they are understood that heat-resistant crack nature is inadequate. moreover, example of this invention No.2 No. -- 6 and 7 From comparison, abrasion resistance and heat-resistant crack nature are further improved by making Co contain.

[0044] example of this invention No.5 No. -- 8 and 9 From comparison, abrasion resistance is improving further by containing Ti and Zr.

[0045] Furthermore, example of this invention When Co, Ti, and Zr contain like No.11, abrasion resistance, heat-resistant crack nature, and surface deterioration-proof nature are improving with sufficient balance.

[Translation done.]